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RECENT FLOW VISUALIZATION STUDIES IN THE 0.3-m TCT

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SCHEMATIC OF TYPICAL FLOW VISUALIZATION SETUP IN 0.3-M TCT

Light beams are altered by refractive index changes and indeed flow induced refractive index changes provides the impetus for conventional visualization techniques such as schlieren and shadowgraph. Unfortunately effects related to the flow can be masked by refractive index inhomogeneities external to the test section. For high-pressure cryogenic facilities this is especially true in the interface between the region of test and the more benign environment where equipment is housed. Since the refractive index is directly proportional to density, it depends upon pressure and temperature through the ideal gas law. Even mild temperature inhomogeneities can be detrimental when coupled with high pressures as occurs in the plenum. The simple shadowgraph scheme depicted in figure 1 was used to assess the flow quality of the Langley 0.3-Meter Transonic Cryogenic Tunnel. The light source was a pulsed (15 microsecond) 75-watt xenon arc lamp focused onto a 0.51 mm diameter pinhole. Light was collimated with an f/8 mirror with a 1.22-m focal length. Data were recorded on film with a 70mm format reflex camera.

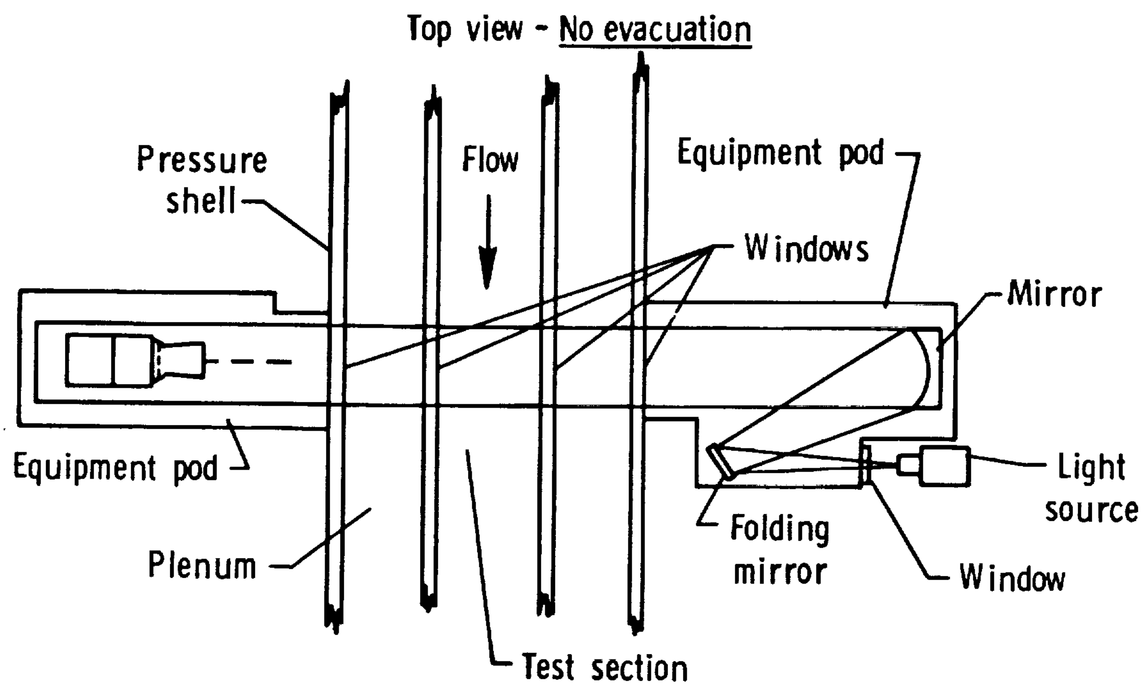

Figure 1

REPRESENTATIVE SHADOWGRAPH RESULTS PRIOR TO IMPROVEMENTS

The simple shadowgraph scheme depicted in figure 1 was used to characterize the flow quality of the Langley 0.3-Meter TCT with results shown in figure 2. This collage of photos was taken at Mach 0.65 conditions with stagnation pressure and temperature as indicated. The completely uniform light field which characterizes the pretest condition becomes increasingly mottled and jumbled as temperature decreases and pressure increases. This behavior is typical of earlier optical experiments conducted in this facility (see refs. 41, 42, and 43).

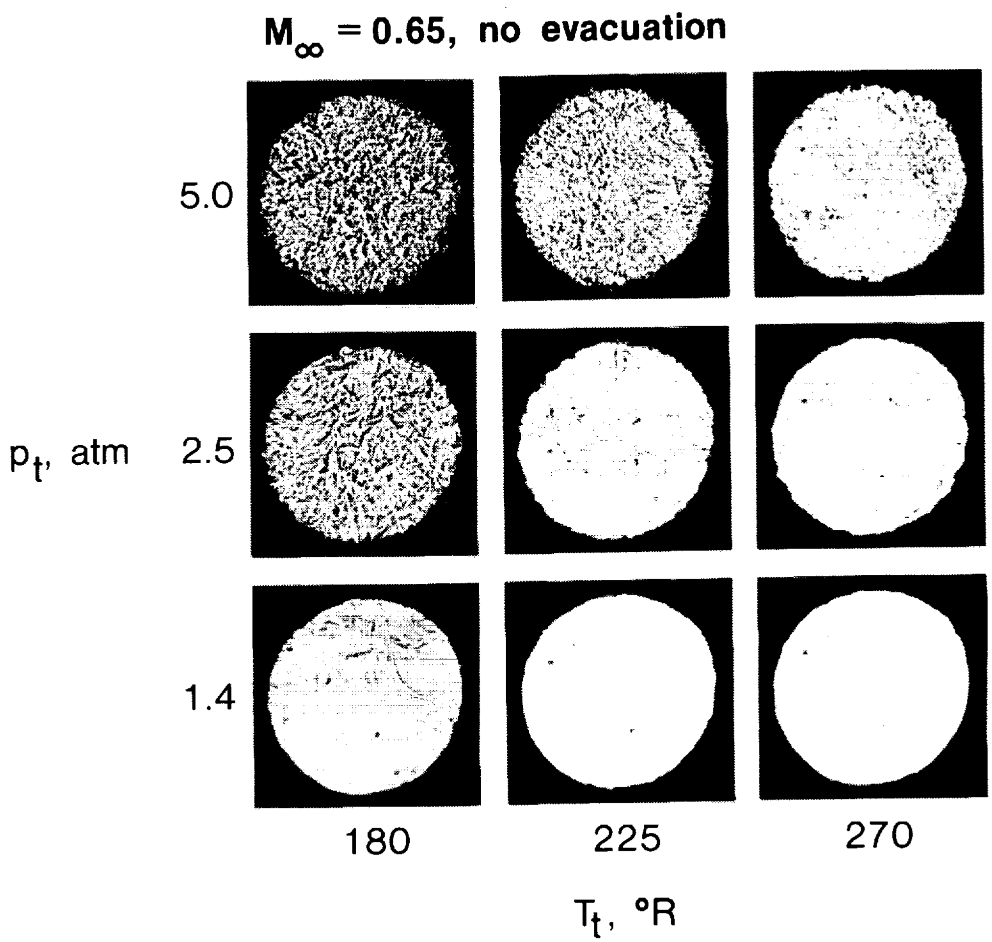

Figure 2

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MODIFIED SHADOWGRAPH SYSTEM TO EXCLUDE PLENUM EFFECTS

Several of the tests devised to determine the source of the image degradation are described in reference 19. The crucial test involved installation of tubes to penetrate the plenum. The tubes could be purged or evacuated to allow direct viewing of the test section. Figure 3 shows the same layout as figure 1 with the hatched area designating the region impacted by the isolation tubes. A bellows type of arrangement was required to accommodate the large differential expansion experienced in the structure of the facility. Details of the assembly are found in the reference.

Top view — With evacuation in equipment pods (cross hatched)

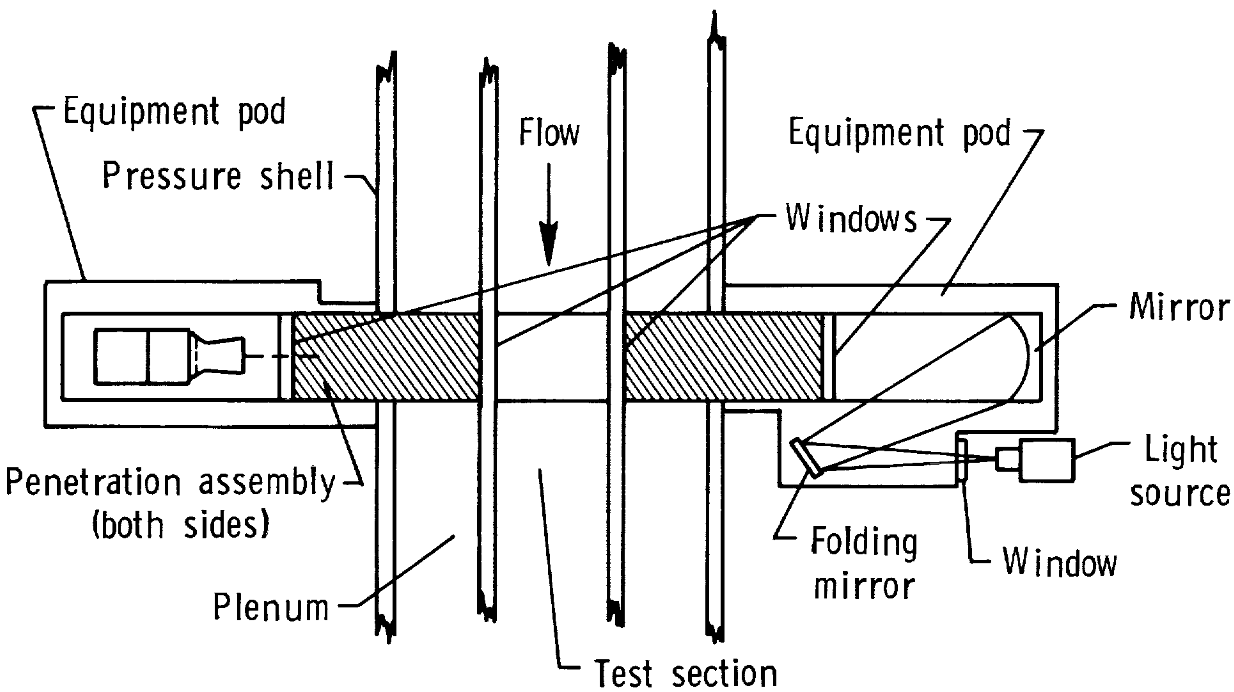
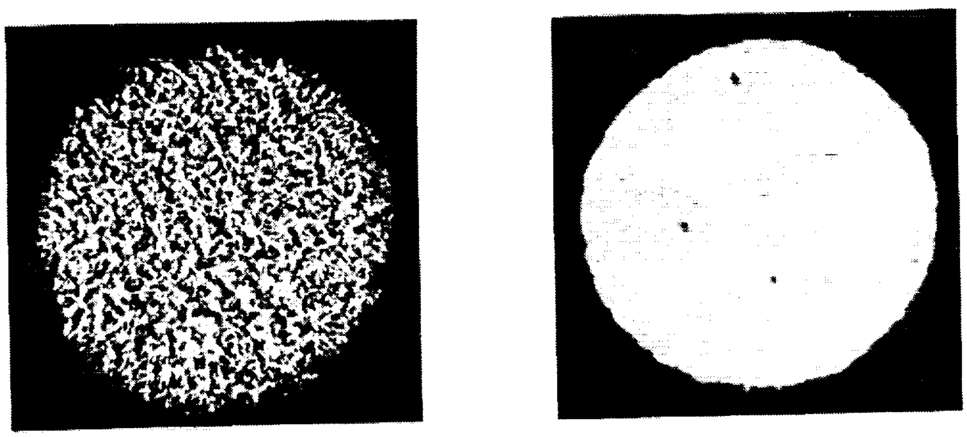


Figure 3

EFFECT OF PLENUM EVACUATION ON SHADOWGRAPH RESULTS

When the penetration tubes were evacuated the quality of the shadowgraphs improved dramatically. Results for the worst test condition of figure 2 (T_t = 180 R, p_t = 5 atm, Mach 0.65) are shown in figure 4. Residual "graininess" in the evacuated case is believed to be due to the flow field itself. Earlier difficulties were brought about by density inhomogeneities in the regions of strong temperature gradients especially in those areas under high pressure. Provisions for evacuated paths to and from the test section should be seriously considered in future flow visualization efforts for facilities of this type. In scaled up cryogenic facilities such as the National Transonic Facility equipment is completely housed within the plenum area (ref. 42). Much of the critical optical path would be in the controlled environment of the equipment enclosures. Nevertheless, regions near windows where extreme temperature gradients occur should be evacuated if possible to lessen the effects of convection induced mixing.



No evacuation With evacuation

Figure 4

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BLACK AND WHITE PHOTOGRAPH

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